Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fishes and megabenthic invertebrates are conspicuous members of continental shelf and slope habitats, and assessment of their communities has become an important focus of ocean monitoring programs throughout the world. Such assemblages have been sampled for more than 30 years on the mainland shelf of the Southern California Bight (SCB), primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). More than 100 species of demersal fish inhabit the SCB, while the megabenthic invertebrate fauna consists of over 200 species (Allen 1982, Allen et al. 1998). For the region surrounding the Point Loma Ocean Outfall (PLOO), the most common trawl-caught fishes include Pacific sanddab, longfin sanddab, Dover sole, hornyhead turbot, California tonguefish, plainfin midshipman, and yellowchin sculpin. Common trawl-caught invertebrates include relatively large taxa such as the sea urchins *Lytechinus pictus* and *Allocentrotus fragilis*, and the sea stars *Luidia foliata* and *Astropecten verrilli*.

The structure of these communities may be influenced by both anthropogenic and natural factors. Demersal fishes and megabenthic invertebrates live in close proximity to sediments potentially altered by anthropogenic influences such as inputs from ocean outfalls and storm drain runoff. Natural factors include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperature associated with large scale oceanographic events such as El Niños (Karinen et al. 1985). These natural factors can impact the migration of adult fish or the recruitment of juveniles into an area (Murawski 1993). The mobile nature of many species (e.g., schools of fish or aggregations of urchins) can result in population fluctuations that affect diversity and abundance measures. All of these influences affect the structure of these communities, making them inherently variable.

The City of San Diego Ocean Monitoring Program was designed to monitor the effects of the Point Loma Ocean Outfall (PLOO) on the local marine environment. This chapter presents analyses and interpretation of demersal fish and megabenthic invertebrate data collected under this program during 2006. A long-term analysis of changes in these communities from 1991 through 2006 is also presented.

MATERIALS AND METHODS

Field Sampling

A total of 12 trawls were performed during 2 surveys off Point Loma in 2006. The area of study extends from about 8 km north to 9 km south of the PLOO. Six stations (SD7, SD8, SD10, SD12, SD13, SD14) are located along the 100-m contour and were sampled during January and July (**Figure 6.1**). A single trawl was performed at each station using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes of bottom time at about 2.5 knots along a predetermined heading.

Each trawl catch was brought on board ship for sorting and inspection. All captured organisms were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. For fish, the total number of individuals and total biomass (wet weight, kg) were recorded for each species. Additionally, each individual fish was inspected for the presence of external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter size class (standard length). For invertebrates, the total number of individuals

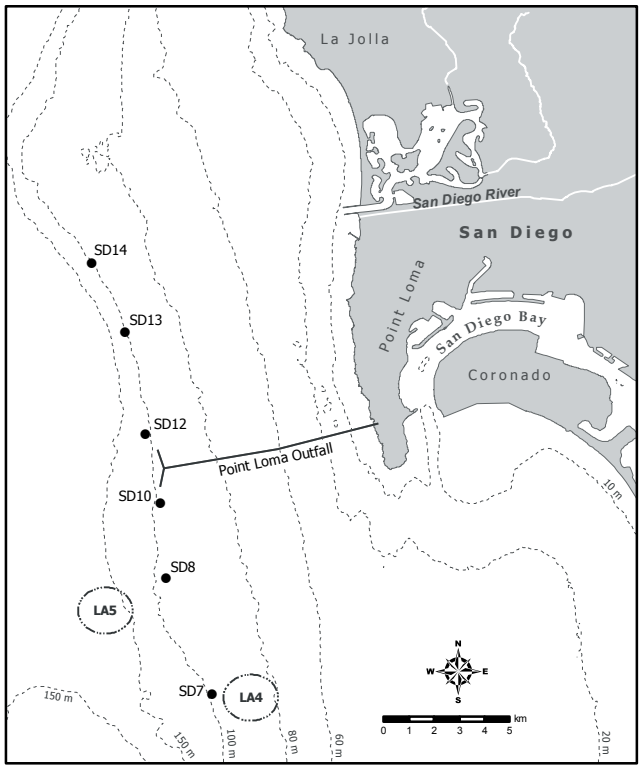

Figure 6.1
Otter trawl station locations, Point Loma Ocean Outfall Monitoring Program.

was recorded per species. When the white sea urchin, *Lytechinus pictus,* was collected in large numbers, its abundance was estimated by multiplying the total number of individuals per 1.0 kg subsample by the total urchin biomass.

Data Analyses

Populations of each fish and invertebrate species were characterized in terms of percent abundance, frequency of occurrence, and mean abundance per occurrence. In addition, species richness (number of species), total abundance, and Shannon diversity index (H') were calculated for both fish and invertebrate assemblages at each station. Total biomass was also calculated for each fish species by station.

Multivariate analyses were performed using data from only the July surveys over the past 16 years (1991-2006). PRIMER software was used to examine spatio-temporal patterns in the overall similarity of fish assemblages in the region (see Clarke 1993, Warwick 1993, Clarke and Gorley 2006). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking, and ordination by non-metric multidimensional scaling (MDS). The fish abundance data were limited to species that occurred in at least 10 hauls, or had a station abundance of 5 or greater. These data were square root transformed, and the Bray-Curtis measure of similarity was used as the basis for classification. Because the species composition was sparse at some stations, a dummy species with a value of 1 was added to all samples prior to computing similarities (see Clarke and Gorley 2006). The SIMPER ("similarity percentages") routine was used to describe inter- and intra- group species differences.

RESULTS

Fish Community

Thirty-nine species of fish were collected in the area surrounding the PLOO during 2006 (**Table 6.1**). The total catch for the year was 6243 fishes representing an average of 520 individuals per haul. Pacific sanddab was the most abundant fish comprising 44% of the total catch (n=2734). This species, as well as halfbanded rockfish, Dover sole, longspine combfish, shortspine combfish, pink seaperch, English sole, hornyhead turbot, and greenstriped rockfish, occurred in every haul. Other common fishes present in at least half of the hauls were yellowchin sculpin, plainfin midshipman, stripetail rockfish, California lizardfish, California tonguefish, greenblotched rockfish, bigmouth sole, and pink rockfish. All of these 17 species were relatively small with average lengths <20 cm (**Appendix C.1**).

In 2006, average abundances of demersal fish ranged from a low of 395 individuals at station SD13 to 793 at station SD10 (**Table 6.2**). These values are generally lower and represent less station variability than was observed in 2005 (City of San Diego 2006). The greatest abundance at station SD10 was due to high numbers of yellowchin

Table 6.1

Demersal fish species collected in 12 trawls in the PLOO region during 2006. Data for each species are expressed as: percent abundance (PA); frequency of occurrence (FO); mean abundance per occurrence (MAO).

Species	PA	FO	MAO
Pacific sanddab	44	100	228
Halfbanded rockfish	20	100	107
Dover sole	9	100	45
Yellowchin sculpin	8	67	63
Longspine combfish	5	100	27
Shortspine combfish	3	100	13
Pink seaperch	1	100	7
Plainfin midshipman	1	92	8
English sole	1	100	7
Stripetail rockfish	1	83	6
California lizardfish	1	92	4
Roughback sculpin	1	42	9
Hornyhead turbot	1	100	4
Greenstriped rockfish	1	100	3
California tonguefish	1	67	4
Spotfin sculpin	<1	25	9
Slender sole	<1	33	5
Greenblotched rockfish	<1	67	2
Bigmouth sole	<1	58	3
Pink rockfish	<1	50	3
Blackbelly eelpout	<1	42	3
Pacific argentine	<1	25	5
California scorpionfish	<1	33	2
California skate	<1	42	1
Blacktip poacher	<1	42	1
Spotted cuskeel	<1	17	2
Spotted ratfish	<1	17	2
Bluebanded ronquil	<1	17	1
Bluespotted poacher	<1	17	1
Flag rockfish	<1	17	1
Pygmy poacher	<1	17	1
Starry skate	<1	17	1
White croaker	<1	17	1
Bluebarred prickleback	<1	8	1
Chub mackerel	<1	8	1
Greenspotted rockfish	<1	8	1
Lingcod	<1	8	1
Shortbelly rockfish	<1	8	1
Squarespot rockfish	<1	8	1

sculpin and halfbanded rockfish (**Appendix C.2**). On average, the smallest haul occurred north of the PLOO at station SD13, which contrasts the typical pattern of lower abundances at the southernmost stations SD 7 and SD8 (e.g., see Figure 6.2).

Table 6.2

Summary of demersal fish community parameters for PLOO stations sampled during 2006. Data are presented for cumulative (total) and mean number of species, abundance (abund), diversity (H'), and biomass (BM; kg, wet weight); n=2 surveys.

	No. of Species				
Station	Total	Mean	Abund	H'	BM
SD7	28	22	431	1.94	6.4
SD8	30	23	462	1.72	9.2
SD10	21	18	793	1.39	11.9
SD12	19	16	516	1.81	10.3
SD13	22	18	395	1.36	12.9
SD14	24	21	525	1.44	14.2

The total biomass of fishes captured at each station was also lower and less variable in 2006 relative to prior years. Biomass values ranged from 6.4 kg at the southernmost station (SD7) to 14.2 kg at the northernmost station (SD14). The highest biomass did not always coincide with the largest hauls, but instead reflected the collection of larger fish. For example, station SD13 had the fewest individuals on average, but the second highest biomass. In contrast, station SD10 averaged the most fish per haul, but had only the third highest biomass. This difference is due, in part, to larger Pacific sanddabs collected at SD13 in July. These fish averaged 50 g at SD13, 40 g at SD14, and ≤20 g at the all other stations (**Appendix C.3**).

As in previous years, values for species richness and diversity (H') varied little during 2006 (Table 6.2). The mean number of species ranged from 16 to 23 per haul, while the (cumulative) total number of species was 30 or less at all stations over the year. These species richness values are higher than those found for the shallower stations sampled as part of the South Bay monitoring program (City of San Diego 2007), but are similar to median SCB values for the same depths (Allen et al. 1998). Average diversity (H') values for the PLOO region ranged from 1.36 to 1.94, with stations SD7, SD8, and SD12 having values >1.5, which is

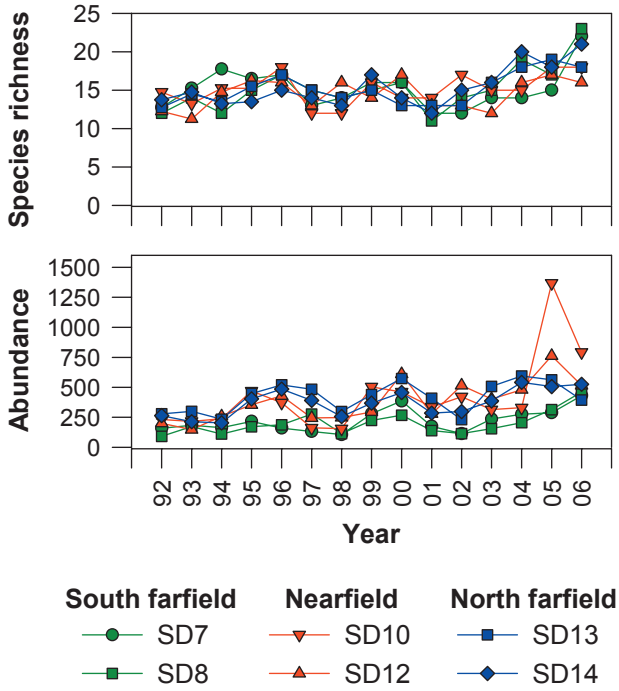

Figure 6.2

Annual mean species richness (number of species) and abundance (number of individuals) per PLOO station of demersal fish collected from 1992 through 2006; n=4 1992–2002, n=3 in 2003, and n=2 during 2004–2006.

the median for the SCB region (see Allen et al. 1998, 2002). These diversity values are typical for the southern region of the SCB, and are a result of the predominance of a few species such as Pacific sanddabs, halfbanded rockfish, and yellowchin sculpin.

Large fluctuations in populations of a few dominant species have been the primary factor contributing to the high variation in fish community structure off Point Loma since 1992 (**Figure 6.2, Figure 6.3**). For example, species richness has consistently averaged from 10 to 23 species per station, while mean abundances have varied between 93 and 1368 individuals (Figure 6.2). These fluctuations in abundance have been greatest at stations SD10, SD12, SD13, SD14 and generally reflect differences in populations of several dominant species, especially the Pacific sanddab (Figure 6.3). These 4 stations also had fairly similar patterns of change in the dominant species through time. None of the observed changes appear to be associated with wastewater discharge from the Point Loma outfall.

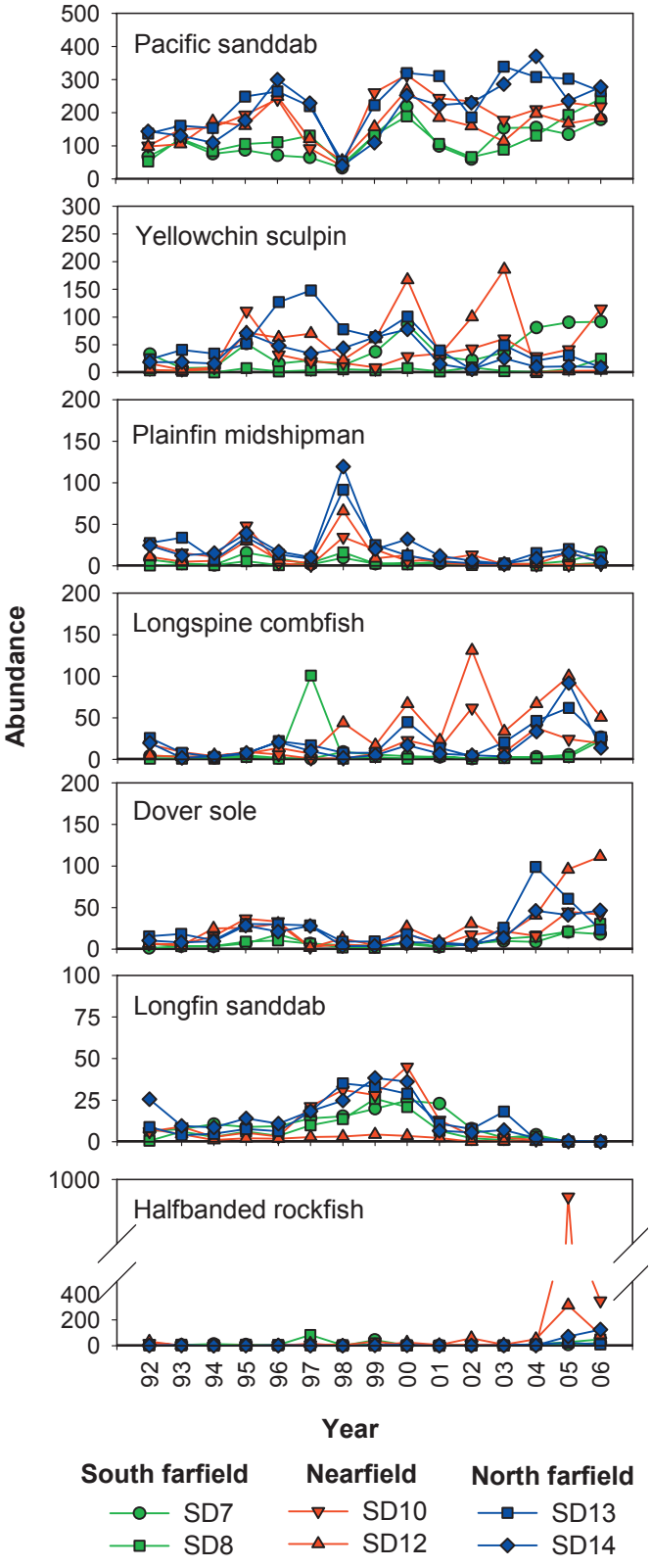

Figure 6.3

Annual mean abundance (number of individuals) per PLOO station for the 7 most abundant fish species collected from 1992 through 2006; n=4 1992–2002, n=3 in 2003, and n=2 during 2004–2006.

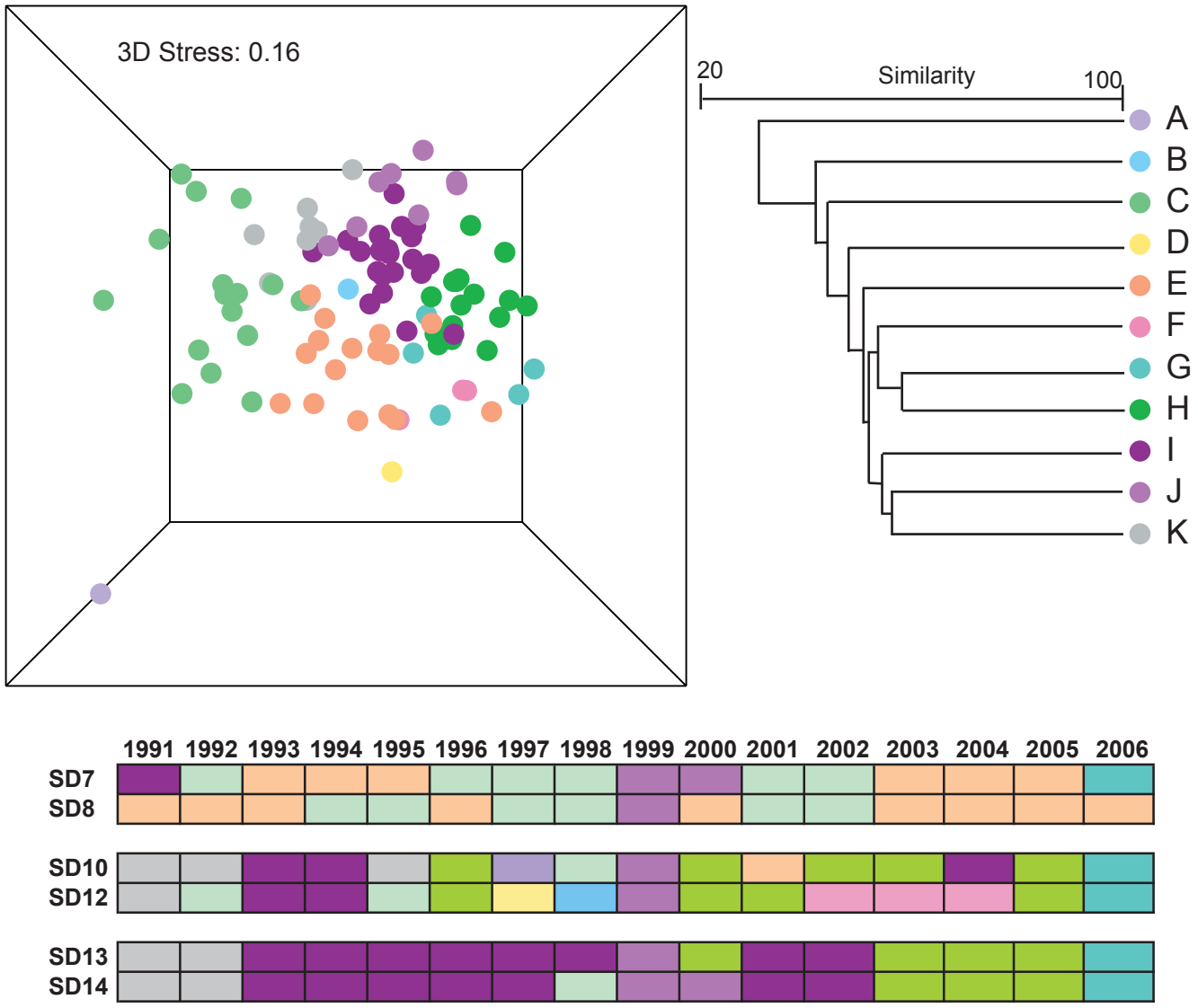

Figure 6.4

Results of ordination and classification analysis of demersal fish collected at PLOO stations SD7–SD14 between 1991 and 2006 (July surveys only). Data are also presented as a matrix showing distribution over time.

Ordination and classification analyses of fish abundance data from the July surveys between 1991 and 2006 indicate that the demersal fish community in the Point Loma area is dominated by Pacific sanddabs, with differences in relative abundances of this and other common species discriminating various sub-assemblages (station groups A–K; see **Figure 6.4**). No patterns of change in fish assemblages were associated with the onset of discharge from the PLOO; the composition of fish that occurred at stations SD10 and SD12 in 1994 was present prior to discharge and was similar to the composition at northern reference stations (SD13, SD14). However, the sub-assemblages occurring at SD10 and SD12 have varied more over time than has either pair of reference sites, particularly during the period 1995–1998. For example, 11 different sub-assemblages were identified from stations SD10 and SD12 from 1997–2006, while 6 or fewer were identified from the northern and southern sites. The differences between these sub-assemblages are slight however, and are likely related to site-specific topography, sediments, or the occasional collection of atypical species (e.g., rockfish) at stations SD10 and SD12. The overriding causes of differences between assemblages through time relate more to

Table 6.3

Description of station groups A–K defined in Figure 6.4. Data include mean abundance of species that together account for 90% of the similarity (or 90% of total abundance when groups have n <2). Values in bold type indicate the species that are most representative of a station group (i.e., 3 species with the highest similarity/SD values >2 for station groups with n >2, or highest abundance for groups with n ≤2).

	Group A	Group B	Group C	Group D	Group E	Group F	Group G	Group H	Group I	Group J	Group K
Number of hauls	1	1	16	1	16	3	5	16	21	8	8
Overall similarity	NA	NA	62	NA	66	69	57	72	75	67	65
Mean species richness	7	14	11	17	16	13	17	16	14	14	11
Mean abundance	44	259	92	224	222	312	482	471	293	375	220
Species	**Mean abundance**										
Pacific sanddab	**23**	**75**	**58**	**110**	**153**	**131**	**197**	**308**	**204**	**227**	**116**
Halfbanded rockfish	**16**			**60**		39	180				
Dover sole		**36**	8		**15**	**31**	**40**	**49**	24		**15**
Longspine combfish		**7**				46	9	**30**			
Shortspine combfish					7						
Spotfin sculpin					6						
Longfin sanddab			5							**26**	
Plainfin midshipman		**116**									**44**
Slender sole						**24**					
Stripetail rockfish										47	
Yellowchin sculpin			4						10	30	
Squarespot rockfish				**23**							
Greenblotched rockfish				8							

oceanographic events (e.g., El Niño conditions in 1998) or location (i.e., station) than to discharge through the PLOO. For example, station groups G, J, and K represent assemblages impacted by shifting ocean temperatures (see Chapter 2), while groups C and E are indicative of the different assemblages at stations SD7 and SD8 relative to those around the outfall and northward. Station group G comprised all but one station surveyed in 2006 (see below) and may be a response to cooler bottom water temperatures (see Chapter 2).

Overall, the 11 major cluster groups consisted of fishes from 1 to 21 hauls comprised of only 7 to 17 species per assemblage. Abundances among the station groups varied widely, with 44 to 482 individuals per assemblage. The species that characterized each assemblage (see **Table 6.3**) and the species that differentiated between assemblages (see **Appendix C.4**) are detailed below**.**

Station group A: The fishes identified from a single trawl at station SD10 in July 1997 formed a group. This trawl included only 7 species and a total of 44 fishes, 87% of which were Pacific sanddabs and halfbanded rockfish. The low number of fishes present may have been due to the amount of time the net was in contact with the bottom during the 10 minutes it was being towed. Reduced catches such as this one can occur if the net bounces along the bottom.

Station group B: Group B comprised a single trawl conducted at station SD12 in 1998. Relatively high numbers of plainfin midshipman and the presence of gulf sanddabs differentiated this assemblage from the others. However, an analysis of all 4 quarters of the 1998 data did not distinguish this as a unique assemblage during that year (see City of San Diego 1999).

Station group C: This assemblage of fishes occurred over several surveys at stations SD7 and/or SD8,

at 4 of 6 stations surveyed during the 1998 El Niño, and at station SD12 in 1992 and 1995. Relatively low numbers of species and low abundances, including the second lowest number of Pacific sanddabs, characterized the group. The low numbers of Pacific sandabs and absence of other cold water species (e.g., Dover sole) differentiated this group of fishes. Lower numbers of Pacific sanddabs are common at stations SD7 and SD8 but not at other stations comprising this station group (i.e., SD10, SD12, SD14) (see Figure 6.3). The low numbers of Pacific sanddabs and Dover sole differentiated the assemblages at stations SD10, SD12, and SD14 during these years from most other surveys conducted at these stations (i.e., groups F, G, H, I, K).

Station group D: As with station groups A and B, group D was comprised of a single trawl: station SD12 sampled in 1997. Group D had considerably higher species richness and numbers of fishes than group A and was dominated by Pacific sanddabs and halfbanded rockfish. This collection of fish was unique in the relatively high numbers of squarespot rockfish and greenblotched rockfish.

Station group E: This assemblage occurred at stations SD7 and SD8 almost exclusively. This group, in combination with group C, characterized all but one survey at SD8, and all but 4 surveys at SD7. Moderate numbers of Pacific sanddabs and Dover sole characterized group E. The relative abundance of these 2 species, together with the shortspine combfish, differentiated these hauls from the others.

Station group F: Moderate numbers of Pacific sanddabs and Dover sole and relatively high numbers of slender sole represented 3 hauls taken at SD12 during 2002, 2003, and 2004. lowchin sculpin and halfbanded rockfish also helped differentiate this assemblage.

Station group G: With the exception of station SD8, fishes present at most stations sampled during July 2006 formed Group G. This group was characterized by high species richness and the highest mean abundance of all the groups, the latter due to large catches of Pacific sanddab and halfbanded rockfish. Comparatively large numbers of Dover sole and the presence of pink seaperch differentiated this station group from the others.

Station group H: This assemblage generally occurred at stations located around the outfall (SD10, SD12) and/or to the north (SD13, SD14) sampled during 1996 and between 2000 and 2005. This collection of fish averaged the highest numbers of Pacific sanddab and Dover sole, and was also characterized by longspine combfish.

Station group I: The species comprising group I occurred over several years of surveys at stations SD13 and/or SD14 and a few years at SD10 and SD12. Dover sole was also fairly abundant in this group, which helped differentiate it from other similar assemblages (e.g., groups A, B, D, F).

Station group J: Group J occurred at all stations sampled in 1999, and at stations SD7 and SD14 sampled in 2000. This assemblage had the second highest numbers of Pacific sanddab, but the presence of longfin sanddabs differentiated this group from all others. Longfin sanddabs are typically considered a shallower, warmer water species than Pacific sanddabs. The higher abundance of longfin sanddabs in 1999 was likely due to the warmer waters associated with the El Niño that had occurred the previous year.

Station group K: This assembly of fishes occurred in the summers of 1991 and 1992 at station SD10 north to SD14. It was characterized by moderate numbers of Pacific sanddabs, Dover sole, and relatively high numbers of plainfin midshipman.

Physical Abnormalities and Parasitism

Occurrences of disease or other physical abnormalities were generally low (<1%) in fish populations off Point Loma during 2006. For example, there were no incidences of fin rot, while only 3 Dover soles (less than 1% of the sampled Dover sole population) were found to

Table 6.4

Megabenthic invertebrate species collected in 12 trawls in the PLOO region during 2006. Data for each species are expressed as: percent abundance (PA); frequency of occurrence (FO); mean abundance per occurrence (MAO).

Species	PA	FO	MAO
Lytechinus pictus	89	100	1491
Allocentrotus fragilis	5	75	103
Acanthoptilum sp	4	58	105
Luidia foliolata	1	92	10
Parastichopus californicus	<1	83	6
Sicyonia ingentis	<1	92	8
Ophiura luetkenii	<1	58	5
Astropecten verrilli	<1	58	4
Octopus rubescens	<1	75	2
Florometra serratissima	<1	50	3
Pleurobranchaea californica	<1	50	2
Spatangus californicus	<1	42	2
Rossia pacifica	<1	42	2
Paguristes turgidus	<1	42	1
Platymera gaudichaudii	<1	33	2
Tritonia diomedea	<1	25	2
Brissopsis pacifica	<1	17	3
Armina californica	<1	17	2
Luidia asthenosoma	<1	8	3
Megasurcula carpenteriana	<1	17	2
Thesea sp B	<1	25	1
Metridium farcimen	<1	17	1
Ophiothrix spiculata	<1	17	1
Suberites suberea	<1	17	1
Cancellaria cooperii	<1	8	1
Cancellaria crawfordiana	<1	8	1
Hemisquilla californiensis	<1	8	1
Henricia leviuscula	<1	8	1
Nassarius insculptus	<1	8	1
Neocrangon zacae	<1	8	1
Neosimnia barbarensis	<1	8	1
Paralithodes californiensis	<1	8	1
Philine auriformis	<1	8	1
Platydoris macfarlandi	<1	8	1
Podochela hemphillii	<1	8	1
Podochela lobifrons	<1	8	1

have any tumors. These tumors were likely from a Dover specific infection, and have not been associated with degraded environments (Dr. M. J. Allen, SCCWRP, personal communication). The copepod eye parasite *Phrixocephalus cincinnatus* occurred on 2% of the Pacific sanddabs collected and was present at all stations during all surveys.

Table 6.5

Summary of megabenthic invertebrate community parameters for PLOO stations sampled during 2006. Data are presented for cumulative (total) and mean number of species, abundance (abund), and diversity (H'); n=2 surveys.

	No. of species			
Station	Total	Mean	Abund	H'
SD7	23	16	1890	0.24
SD8	13	9	3551	0.08
SD10	15	11	2021	0.13
SD12	18	13	1493	0.76
SD13	17	13	706	0.80
SD14	16	12	339	0.92

Invertebrate Community

A total of 19,994 megabenthic invertebrates, representing 36 species, were collected during 2006 (**Table 6.4**, **Appendix C.4**). The white sea urchin *Lytechinus pictus* was the most abundant and most frequently captured species. It was the only species present in all trawls and accounted for 89% of the total invertebrate catch. Other common species that occurred in more than half of the hauls included the sea urchin *Allocentrotus fragilis*, the sea pen *Acanthoptilum* sp, the sea stars *Astropecten verrilli* and *Luidia foliolata*, the brittle star *Ophiura luetkenii,* the sea cucumber *Parastichopus californicus*, the shrimp *Sicyonia ingentis*, and the octopus *Octopus rubescens*.

Abundance, species richness, and diversity values for the megabenthic invertebrate assemblages varied among stations and between surveys (**Table 6.5, Appendix C.5**). For example, abundance per station averaged from 339 to 3551 individuals. Stations SD13 and SD14 had much lower abundances than the other 4 stations, due to relatively small catches of *Lytechinus pictus*. Diversity values were extremely low (<1) for the entire area due to the numerical dominance of this sea urchin. Dominance of *L. pictus* is typical for these types of habitats throughout the SCB (e.g., Allen et al. 1998).

Invertebrate species richness and abundance have varied over time (**Figure 6.5**). Annual species richness has averaged from 5 to 20 species since 1992, although

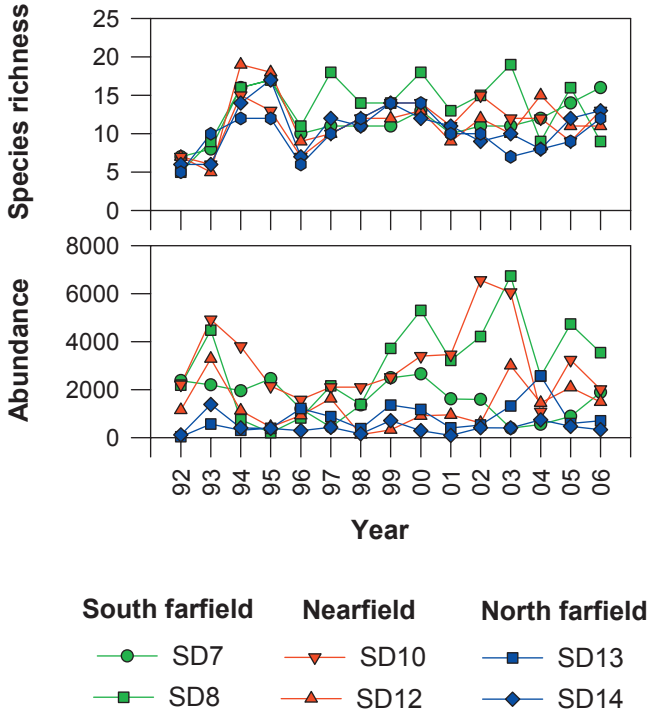

Figure 6.5

Annual mean species richness (number of species) and abundance (number of individuals) per PLOO station of megabenthic invertebrates collected from 1992 through 2006; n=4 1992–2002, n=3 in 2003, and n=2 during 2004–2006.

the patterns of change have been similar among stations. In contrast, changes in abundance have differed greatly among stations. The average annual invertebrate catches have been consistently low at stations SD13 and SD14, while the remaining stations have demonstrated large fluctuations in abundance. These fluctuations typically reflect changes in *L. pictus* populations, as well as the urchin *Allocentrotus fragilis*, and, to a lesser degree, the sea pen *Acanthoptilum* sp (**Figure 6.6**). The abundances of these 3 taxa are much lower at the 2 northern sites, which likely reflects differences in sediment composition (e.g., fine sands vs. mixed coarse/fine sediments, see Chapter 4). None of the observed variability in the invertebrate community could be attributed to the discharge of wastewater from the PLOO.

SUMMARY AND CONCLUSIONS

As in previous years, Pacific sanddabs continued to dominate fish assemblages surrounding the Point

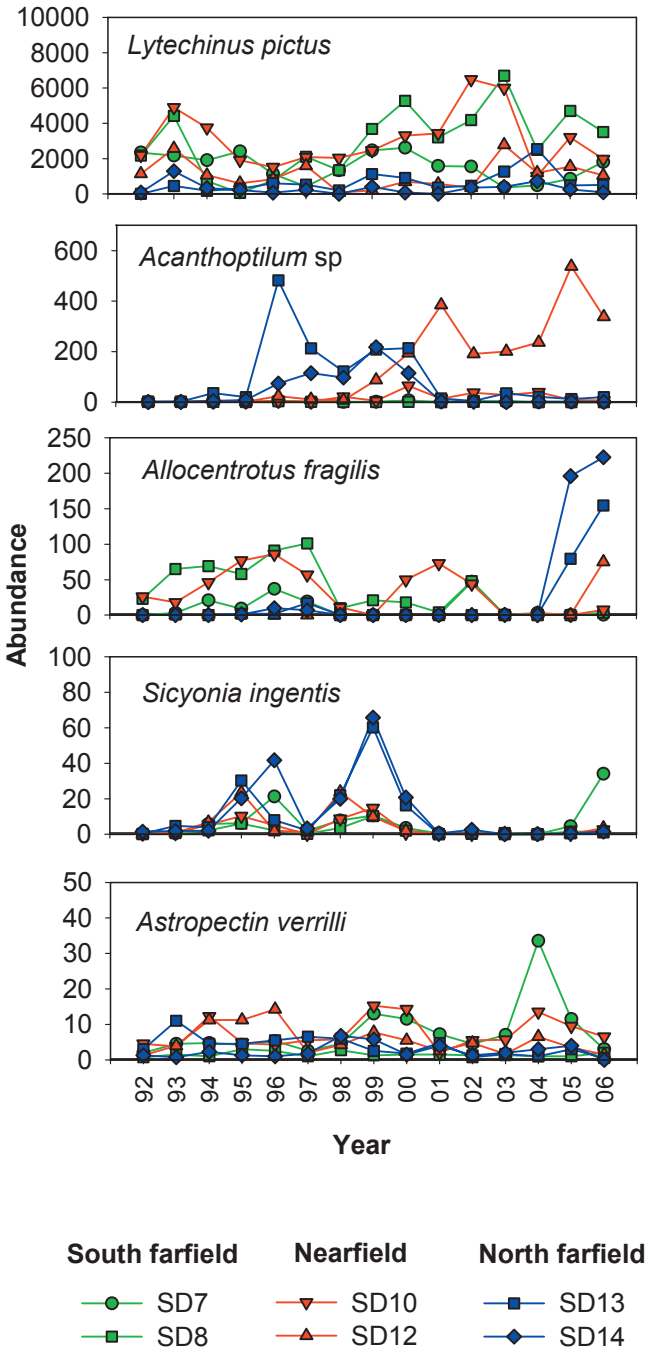

Figure 6.6

Annual mean abundance (number of individuals) per PLOO station for the 5 most abundant megabenthic invertebrate species collected from 1992 through 2006; n=4 1992–2002, n=3 in 2003, and n=2 during 2004–2006.

Loma Ocean Outfall during 2006. These fish were present in relatively high numbers at all stations. Other characteristic, but less abundant species, included halfbanded rockfish, Dover sole, longspine combfish, shortspine combfish, pink seaperch, English sole, hornyhead turbot, greenstriped rockfish,

yellowchin sculpin, plainfin midshipman, stripetail rockfish, California lizardfish, California tonguefish, greenblotched rockfish, bigmouth sole, and pink rockfish. Although the composition and structure of the fish assemblages varied among stations, most differences were due to fluctuations in Pacific sanddab populations.

Assemblages of megabenthic invertebrates were also dominated by a single prominent species, the white sea urchin *Lytechinus pictus.* Other common species included the sea urchin *Allocentrotus fragilis*, the sea pen *Acanthoptilum* sp, the sea stars *Astropecten verrilli* and *Luidia foliolata*, the brittle star *Ophiura luetkenii,* the sea cucumber *Parastichopus californicus*, the shrimp *Sicyonia ingentis*, and the octopus *Octopus rubescens*. Although megabenthic community structure varied between sites, these assemblages were generally characterized by low species richness and diversity. Abundance was proportional to the number of *L. pictus* collected in each haul.

Overall, results of the trawl surveys conducted in 2006 provide no strong evidence that the discharge of wastewater from the Point Loma Ocean Outfall affected fish or megabenthic invertebrate communities in the region during the year. Although highly variable, patterns in the abundance and distribution of species were similar at stations located near the outfall and further away. Changes in these communities that have occurred over time appear to be due to natural factors such as changes in water temperature associated with large scale oceanographic events (El Niño), sediment conditions, and the mobile nature of many of the species collected. Finally, the general absence of disease or physical abnormalities on local fishes suggests that populations in the area continue to be healthy.

LITERATURE CITED

Allen, M.J. (1982). Functional structure of soft-bottom fish communities of the southern California shelf. Ph.D. dissertation. University of California, San Diego. La Jolla, CA. 577 p.

Allen, M.J., S.L. Moore, K.C. Schiff, S.B. Weisberg, D. Diener, J.K. Stull, A. Groce, J. Mubarak, C.L. Tang, and R. Gartman. (1998). Southern California Bight 1994 Pilot Project: Chapter V. Demersal Fishes and Megabenthic Invertebrates. Southern California Coastal Water Research Project, Westminster, CA. 324 p.

Allen, M. J., A. K. Groce, D. Diener, J. Brown, S. A. Steinert, G. Deets, J. A. Noblet, S. L. Moore, D. Diehl, E. T. Jarvis, V. Raco-Rands, C. Thomas, Y. Ralph, R. Gartman, D. Cadien, S. B. Weisberg, and T. Mikel. 2002. Southern California Bight 1998 Regional Monitoring Program: V. Demersal Fishes and Megabenthic Invertebrates. Southern California Coastal Water Research Project. Westminster, CA. 572 p.

City of San Diego. (1999). Receiving Waters Monitoring Report for the Point Loma Ocean Outfall, 1998. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2006). Annual Receiving Waters Monitoring Report for the Point Loma Ocean Outfall, 2005. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2007). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (South Bay Water Reclamation Plant), 2006. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

Clarke, K.R. (1993). Non-parametric multivariate analyses of changes in community structure. Aust. J. Ecol., 18: 117–143.

Clarke, K.R., R.N. Gorley. (2006). Primer v6: User Manual/Tutorial. PRIMER-E: Plymouth. 190 p.

Cross, J.N., and L.G. Allen. (1993). Chapter 9. Fishes. In: Dailey, M.D., D.J. Reish, and J.W. Anderson, eds. Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. p. 459–540.

Cross, J.N., J.N. Roney, and G.S. Kleppel. (1985). Fish food habitats along a pollution gradient. California Fish and Game, 71: 28–39.

Helvey, M., and R.W. Smith. (1985). Influence of habitat structure on the fish assemblages associated with two cooling-water intake structures in southern California. Bull. Mar. Sci., 37: 189–199.

Karinen, J.B., B.L. Wing, and R.R. Straty. (1985). Records and sightings of fish and invertebrates in the eastern Gulf of Alaska and oceanic phenomena related to the 1983 El Niño event. In: Wooster, W.S. and D.L. Fluharty, eds. El Niño North: El Niño Effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant Program. p. 253–267.

Murawski, S.A. (1993). Climate change and marine fish distribution: forecasting from historical analogy. Trans. Amer. Fish. Soc., 122: 647–658.

Warwick, R.M. (1993). Environmental impact studies on marine communities: pragmatical considerations. Aust. J. Ecol., 18: 63–80.

This page intentionally left blank